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INFORMATIONAL NEEDS IN SCIENCE
AND TECHNOLOGY

By Charles L. Reese

Chemical Director, E. I. du Pont de Nemours & Company

UNIVERSITY OF CALIFORNIA
AT LOS ANGELES

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REPRINT AND CIRCULAR SERIES
OF THE
NATIONAL RESEARCH COUNCIL

NUMBER 33

Informational Needs in Science and
Technology

By Charles L. Reese

THERE is a common saying that "Knowledge is Power." Information and knowledge are so closely related that it might be said that information is power, and coordinated information is power plus. The rapid rate at which knowledge has been and is being accumulated, particularly in science and technology, is brought out very forcibly by the Polish engineer Korzybski in his remarkable book, "Manhood of Humanity," and it seems that extraordinary steps must be taken to coordinate and correlate information in such a way as to make it available to all capable of using it throughout the world.

Efficiency in research and in the application of its results is significantly conditioned by command of information. To the individual, nation, or race which most skilfully, thoroughly, and wisely masters and uses the accumulated knowledge of mankind comes supremacy in industry, if not also in science, politics, and art. Creators of knowledge through the application of scientific method to Nature are prone to belittle or to ignore the devices by which information is conserved, rendered conveniently accessible, and disseminated. Rather it becomes us to inquire whether by giving systematic attention to means of marshaling and using what has been discovered, invented, felt, imagined, constructed, we may not render uniquely valuable service to civilization.

Time was when knowledge was transmitted from man to man or generation to generation either orally or by rude products of human labor. Then came written language and, finally, printing, libraries, and the construction of such keys to knowledge as catalogs, indexes, handbooks, encyclopedias. All the while the rate of accession to information has increased rapidly, although irregularly. Man has become increasingly a thinking animal with remarkable development of curiosity, resourcefulness, originality, breadth of interest and view, foresight, disinterestedness, and sympathy. With multitudes of individuals and generations feverishly active, often progressive,

all striving to live more comfortably, happily, usefully and longer, and to command Nature more successfully to these ends, what are the chances that my present idea, thought, or plan is new—shall we say one in a million? It requires but scant attention to the matter to convince us that the efficiency of our use of the products of human thought and of its records is astoundingly low. We chemists are continuously repeating not only mental processes but, as well, the experimental procedures of our predecessors in research. Within limits this duplication of labor is desirable and profitable, but how far we fall short of utilizing as we should the constructive efforts of those unnumbered generations of men and women whose lives prepared the way for ours.

The progress of discovery and invention has nearly eliminated space as a barrier between individuals and peoples. Time, it has been compressed. The output of carefully recorded information is to-day overwhelmingly large—the world is producing millions of printed, typed and written pages of records of research, invention, development, and practical experience, not to mention cultural and esthetic creations. This amazing increase in the quantity of human knowledge is accompanied by corresponding increase in specialization of interest, occupation, and terminology. Tongues also have multiplied, and mental patterns, human needs, and demands have become more diverse. In general, as knowledge has increased, the devices for handling it have become less satisfactory. Few needs are now clearer or more urgent than the construction of efficient informational mechanisms or keys to knowledge. The question I present to you is, "How may the constructive agencies in science and industry help to bring about the designing and installation of suitable informational mechanisms?" May we not profitably bring our scientific method, habit of mind, purpose, and need to bear on this important problem with a view to devising informational master-keys which shall render human knowledge many times more available and, therefore, more valuable?

It is obvious that knowledge, even in a relatively narrow field, has outgrown the capacity of most individuals. However encyclopedic we may be by nature or training, we can master only certain fragments of the information which mankind has accumulated. It is conceivable, however, that we should be able to construct an informational system which would enable every reasonably intelligent and fairly well-educated person to obtain the essential information about a given subject when needed. Why should we not handle the packing, storage, shipping, and distribution of knowledge as efficiently as we manage commercial production? We have gradually devised a system of exchange, national and international, which with reasonable satisfactoriness enables us to enjoy the products of others' skill and industry. Such systems are imperfect, but by comparison with present modes of preserving information and rendering it accessible to posterity, they are highly advanced.

Largely because knowledge is discontinuous and relatively

unavailable, history repeats itself endlessly and tragically. Ignorance, it would appear, is responsible for more catastrophes and racial setbacks than are carelessness, selfishness, and maliciousness combined. The solemn duty rests on us to devise adequate ways and means of carrying forward always, with continuously increasing accessibility, the sum of useful knowledge and experience. The fact that the task has not been done is good evidence of its difficultness, not of its impossibility or its lack of importance.

DEVELOPMENTS DURING THE WAR

The World War at once revealed some of the weaknesses of our informational position and our ability to remedy them. When the tremendous need for munitions and men came we were plodding along self-satisfied and generally oblivious of the fact that we commanded relatively little information. Almost over night, investigators and industries became aware that knowledge of conditions, discovery, invention, production—in a word, efficiency of effort was lacking. Intelligence bureaus, informational departments, staffs of abstractors, indexers, compilers, and purveyors appeared suddenly all over the country. What Germany had at hand in 1914, because of her superior foresight and appreciation of the supreme value of systematized available knowledge and of the indispensableness of research, we were compelled to try to create at high speed and with feverish haste. It is enlightening to examine some of our information-seeking activities in their relation to our present need and opportunity.

COMMERCIAL ACTIVITIES—My own company, when it undertook a number of new lines of manufacture, beginning during the latter days of the war, recognized the need of more extensive and more comprehensive information along these lines. An Intelligence Division was therefore organized, charged with the collection, integration, and dissemination of technical information on the subjects in which we were interested. At the time of its maximum activity this Division was spending \$80,000 per year for salaries alone, and comprised a personnel of thirty-five men and women.

A classified index of the dye patents of the United States was prepared; foundations were laid for a general information catalog, which, while no longer being added to at the present time, is still a valuable library tool; an information index of our research reports was started and is just being completed; a library was organized, etc. While many of the activities of the Division probably were of interest only to the du Pont Company, it is unquestionably true that some of the activities could better have been carried on by some organization like the Research Information Service of the National Research Council, and the results would then have been available to the country at large.

For more than five years the Chemical Catalog Company has conducted an information bureau for the benefit of chemical industry and its personnel. Informational demands increased so considerably that it was found desirable in 1921 to place this bureau on a charge basis. A fee of \$25 per year is now charged

to firms or individuals who wish to command the service. This also, it should be noted, is a highly specialized service limited to chemical technology and making no special provision for information concerning research.

The National Industrial Conference Board, organized and maintained by the industries of the country, is one of the most active and efficient intelligence agencies in the country. Their activities are mostly along industrial, social, and economic lines, and they have made since 1917 forty-five research reports and twenty special reports as a result of studies on such subjects as changes in cost of living, strikes, works councils, profit sharing, health service in industry, taxes, hours of labor, and metric versus English system of weights and measures. All of these are the results of the collection of statistics and the presentation of facts.

These instances of informational activities directed toward increasing the availability of commercially valuable information are typical of what has been achieved or attempted for various industries throughout the United States since 1917. Many of the informational bureaus which sprang up by reason of war needs have been abandoned because of economic pressure. Others are struggling to achieve self-support and profit. The indications are clear, however, that a general informational clearing house should be an endowed public service organization, independent alike of the need of self-support and of gain.

GOVERNMENTAL WORK—Of governmental informational activities certain notable instances should be mentioned. The Food Administration perfected a staff and statistical machinery which provided it with unprecedentedly complete intelligence concerning food production, distribution, consumption, waste, and prices. The statistical department of the Food Administration, as was generally recognized during the war and has since been made clear by its reports, functioned with marvelous efficiency as an intelligence agency.

With a view to enabling the Federal Government to command such available information as was essential for wise action, a central bureau for planning and statistics was organized and, at the height of the need, operated for several months. But as soon as the need began to diminish this admirable idea and its initial expression were abandoned. Thus was once more exemplified the general inability to appreciate the importance of providing organization and apparatus to make human knowledge readily available.

In the Army and the Navy, intelligence services, with the advent of war, emerged from dark corners and spread knowledge-seeking tentacles throughout the world. Rapidly these military bureaus evolved systems of gathering, classifying, and distributing information of essential importance to a nation at war. For a time the military departments were immersed in positive and negative intelligence, much of which doubtless was generally available to enemies as well as allies. Probably it will require years for these protective and defensive intelligence services to

sink again into that oblivion which ignorance of world conditions tends to encourage. Seemingly, the more ignorant a nation, the safer it feels; and certainly the more ignorant an individual the less he appreciates the possible values of knowledge and of instrumentalities for commanding it.

NATIONAL RESEARCH COUNCIL—Last, because it is first in our interest as investigators, mention may be made of the informational work of the National Research Council. This was begun while the Council served as the Department of Science and Research of the National Council for Defense. At first there was organized a Research Information Committee with headquarters in Washington, and offices in London, Paris, and Rome. The principal and important function of this committee was to gather information about current research of military significance and to distribute reports of such work to appropriate military and civilian agencies. The committee served, through its staff of scientific directors or attachés, primarily as an information gathering and disseminating agency. Its success led to subsequent reorganization as the Research Information Service, concerning which more will be said later.

The various informational activities which have been selected as examples of types are all of them indicative of the need and opportunity which, compelling during the Great War, are always with us and are far more worthy of serious study and effort than is generally realized.

THE WORLD SITUATION

It has already been hinted that there was rare appreciation of the importance of human knowledge during the war and that we already are tending to lose this appreciation. With this observation in mind, it may prove worth while to make a hasty survey of the world situation.

GERMANY—Germany has the instrumentality for commanding scientific and technological information and for stimulation and guidance of research effort which all but gave her victory. This instrumentality, whose principal locus is Grosslichterfelde, includes the great national laboratories and the informational bureau which has quite naturally, but by no means accidentally, grown up in connection with "das königliche Materialprüfungsamt." The purpose of this institution, which was organized at Charlottenburg in 1871 and in 1904 moved to its present site, is to place at the service of the German people a staff of thoroughly competent specialists, armed with all technical facilities and records of human progress. This staff holds itself at the command of investigators, inventors, manufacturers, technologists, agriculturists, to assist in the solution of their practical problems and to help them to command the accumulated knowledge and progress of the whole world. This institution is said to have claimed to be able to answer 80 per cent of the problems put up to them supposedly demanding experimental research.

We may not reasonably flatter ourselves with the thought that we are exceptionally advanced in our consideration of in-

formational needs and opportunities, for the chances are that in Germany, Japan, and probably other countries as well, plans have already been formulated, and possibly are well advanced toward practical expression, for the effective command of world informational resources in the interest of national development and prosperity. But whatever we do toward improving our informational resources, we can least of all afford to forget that as a nation we are backward in supporting, dignifying, and so far recognizing the values of constructive work that it necessarily commands the respect, attention, and confidence of our people, and is regarded as essential to human progress.

Yet, Germany does not stand alone in appreciation of informational need or in determined effort to meet it. England, years ago, was chief mover and responsible agency in the organization of the International Catalog of Scientific Literature, an ambitious project which ultimately failed because it was modeled too closely after the librarian's ideal of an index to knowledge. The Catalog, although undeniably useful as a list of all scientific publications, did not prove satisfactory to investigators and consequently failed to command their support. Its fate points a lesson which it is hoped we may heed, namely, that a mere catalog of titles is an entirely inadequate key to human knowledge. It demands supplementation, transformation, or both.

BELGIUM—Belgium also has witnessed an attempt to list and partly to summarize all published documents. In effect, this amounts to the construction of a classified card catalog to which one might turn with reasonable expectation of getting useful references or suggestions concerning almost any topic of human interest. This project also has suffered the ills of war and is moribund. We well may ask whether the plan was wisely conceived and whether, however thoroughly it may be carried out, it can reasonably be expected to meet our principal informational needs.

As has already been indicated, America, although full of informational agencies—industrial, scientific, political—has no general informational clearing house for all interests. Special informational bureaus or intelligence services come and go so rapidly that a directory cannot be kept to date. Washington is crowded with invaluable sources of information covering the entire range of human interests and activities. There are scores of federal offices, bureaus, divisions, departments which command useful information; but there is no individual and no bureau which serves as guide or directory. Consequently, the search for information in the great national center of intelligence is likely to prove baffling, discouraging, and, at worst, irritating. What could readily be done for informational Washington by the creation of a central clearing house, what indeed already has been attempted for quite another purpose by the Bureau of Efficiency, certainly should be done at once and with the greatest human foresight and skill for our entire country, for the world, because the isolated or independent nation is a fiction, and for the whole of human knowledge, historical as well as current.

Nowhere in the world, so far as present information indicates, is there in plan or operation an informational clearing house conceived on a large scale with intent to render the whole range of human information increasingly accessible and useful. It is precisely such an informational organization that our times, our industries, our investigators, our public institutions, our public servants, and our people need. The realization of need in most quarters is not yet compelling, but in others it is definitely sensed and it is believed that the time is ripe boldly to extend the plans of the Research Information Service of the National Research Council.

RESEARCH INFORMATION SERVICE, NATIONAL RESEARCH
COUNCIL

From the Research Council's committee on research information, following the Armistice, was organized a division of the permanent Council called the "Research Information Service." It was my pleasure and responsibility to assist in planning, organizing, and furthering this informational agency. The Service has now been available for three years. During the first two years attention was centered on the study of the informational situation, the formulation of plans, and the creation of fundamental informational tools. From three years of effort to discover, understand, and satisfy informational demands, certain principles of organization and policy have appeared. These have been carefully considered by an organizing committee which is representative of research interests and of the principal industries and types of informational agency of the country. Foremost among the principles agreed upon by this committee on organization are the following:

1—The desirability of developing initially a general clearing house for scientific and technological information rather than a mere storehouse or depository of knowledge.

2—The conduct of a free informational service for the promotion of research, useful applications of its results and the supplying or disseminating of knowledge necessary for or beneficial to human welfare and progress. It is recognized by the committee that there is a practical limit to the possibility of free service beyond which charge sufficient to cover the cost of service should be made.

3—The encouragement and fostering of a miscellaneous request service initially limited to scientific and technological knowledge which shall strive to supply reliable information concerning any aspect or relations of research. Especially to be mentioned in this connection is information concerning research problems, projects, methods, processes, results, current work, laboratories, equipment, apparatus, funds, and other means of support, persons engaged in constructive or creative work, publications, and bibliographies.

4—The primary task of the special staff of the Research Information Service is set forth as the designing and construction of informational keys, instruments or tools essential to the efficient functioning of a clearing house for human knowledge. The final purpose in endeavoring to create informational instruments is the development of a complete coordinated machinery for gathering, classifying, locating when needed, and disseminating trustworthy information.

5—Utilization by the Service of correspondence, informational publications, and publicity as ways of meeting the informational needs of organizations and individuals, and of educating the public to appreciation of the possible values of a carefully planned and efficiently conducted informational clearing house.

The group of men, among whom appear several of our chemical colleagues, which has been chiefly responsible for the launching and development of this project naturally has come to look upon it as America's most ambitious, most thoughtful, and most promising attempt to be useful in a large way and permanently in connection with the handling of the varied and multitudinous products of human thought and ingenuity. Dr. James R. Angell, first chairman of the post bellum Research Council, once characterized the painstaking, albeit somewhat discouraging, labors of the Research Information Service Committee as primarily an "investment in brains." He believed firmly in the wisdom of this investment and in the supreme importance of the Council's informational opportunity.

To repeat, even casual observation serves to indicate the scattered and special character of sources of knowledge and the extreme improbability that a needy individual will happen upon the right source. It is only by happy accident that one locates satisfactory information outside the field of his special interest and activity. There is neither correlation nor coördination; there is not even a central medium of communication to place those who desire information in touch with those who have it. It is proposed, therefore, to make the Research Information Service of the National Research Council a great clearing house for informational requests and thus to increase the availability and value of existing sources and to supplement them as necessary. The Service will not strive for encyclopedic knowledge, save of sources, but undoubtedly its files will gradually acquire value. Ultimately it may become a great informational center, as well as clearing house.

Although at present the Service is rather strictly limiting its activities to the natural sciences and their practical applications in industry and engineering, it is proposed to direct its development along those lines which promise to promote both increase of human knowledge through constructive effort and improved availability of knowledge already achieved. Once suitable clearing-house machinery has been designed, constructed, and perfected, there is no obvious reason why the plan which has been outlined should not be applied to the entirety of human knowledge.

Although it is commonly believed that the important products of human skill and labor are satisfactorily transmitted from generation to generation it is important to note that this is not true of those products of mental labor which gain expression merely in written language. Useful inventions, commercially developed, are not likely to be lost except by replacement, but verbal descriptions of discoveries or inventions which have not achieved material expression are very likely to become buried in our great informational storehouse, our libraries. In

the light of this condition, it has seemed peculiarly important to develop an informational service to supplement the library. This evidently means new types of keys to knowledge. The staff of the Information Service has planned and begun to develop files for research personnel, problems, results, laboratories, methods, procedures, experimental equipment, and bibliographies. It is surprisingly easy in this kind of venture to design special equipment which cannot be operated successfully because of its needless complexity, size, or costliness. The tendency is always toward specialization and against the creation of efficient clearing-house machinery.

It is now pretty generally recognized that the first and most important step toward increased availability of information should be the preparation of reliable objective, analytical abstracts of literature, and the construction of detailed subject indexes. If the scientific and technological literature of the world were regularly and systematically abstracted and listed, and if all this condensed information were available in the Research Information Service, it is reasonable to anticipate that from 70 to 90 per cent of all requests could be answered directly and with reasonable satisfactoriness from this single master-key. Were this proposed key to published materials supplemented by files of records concerning current research, scientific and technological workers, laboratories—their construction, equipment, etc., it is certain that many more requests could be successfully answered.

The Service has undertaken to develop, as its fundamental tools, first, a list of informational sources including individuals as well as organizations, specialists as well as informational bureaus; second, it is building up a library of source books which it is hoped may ultimately become an invaluable master-key to published information. Scarcely less important than these two types of key for clearing house use is the research personnel file which is counted upon to supply reliable information concerning all research workers, their resources for research, their interests, and their principal lines of activity. This file already contains nearly 14,000 names and is being mechanized by the use of the Findex system for convenience and accuracy of sorting. It is cited merely as an example of a type of master-key which, if skilfully planned and efficiently developed, an informational clearing house is sure to find entirely essential and of steadily increasing value.

As is true in many other directions, the best way to appreciate the problems of an information service, its need, and the value of devices for meeting them, is to try to use the Service and to follow as closely as may be the functioning of the clearing-house mechanisms in supplying information.

American chemists are far better situated informationally than are most other groups of scientists or technologists. Similarly, the chemical industries have been conspicuously more progressive in their efforts to command scientific and technological information than have other commercial interests. To

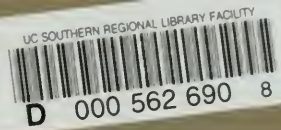
what extent this is due to the necessity created by German initiative and resourcefulness is difficult to determine, but certainly the German influence has been considerable. And with all its provisions for marshaling and promptly commanding pertinent information, it is clear that American chemistry is not in the strongest possible position and that it still must reckon with species of ignorance and forms of competition which are as inimical to national welfare as they are to professional progress. It is entirely fair to ask, "Would not systematic, sustained, intelligent study of informational needs and values be likely to result in great improvement for chemistry?" My own observations and experience in connection with our Chemical Intelligence Department indicate an affirmative reply.

Chemistry and chemists, as well as those who as laymen seek chemical information, undoubtedly can profit greatly by a wisely planned and efficiently conducted general informational clearing house. We especially need such a service to facilitate contacts with related fields of research and with discoveries, inventions, and developments which, although not chemical, have significance for our special interests. We need such a general clearing house also to increase our profitable contacts with the consuming public. We need it to supplement our own keys to chemical literature, our abstracts, indexes, compilations of information, and even our special informational agencies, such as the Chemical Catalog Company, for through the sort of national informational clearing house which the Research Council is undertaking to create our special informational aids in chemistry will be made available to untold millions of scientists, industrialists, and consumers of chemical products.

It is greatly to be desired that ultimately an international service of this character be established with not a single locus, but with branches in most of the important countries, containing on file in each all of the material collected, so that in case of a cataclysm such as has befallen Russia and which might have befallen all of Europe if the World War had lasted much longer, it would not result in the loss to the world of a large part of her wealth of information. Such an arrangement if it were possible would require governmental coöperation but would result in a tremendous saving of effort and be all-embracing.

The Research Information Service of the National Research Council is a public service agency. It is ours to make or to mar, to use or neglect. It urgently invites our coöperation and freely offers its aid to us individually and collectively. We cannot afford to do less than interest ourselves intelligently in this difficult undertaking whose possibilities of usefulness are almost limitless and to endeavor to aid in so directing its further development that it may command our support increasingly.

Before closing I wish to call attention to the valuable results already accomplished by the Research Information Service of the National Research Council, due to the untiring and invaluable efforts of Chairman Robert M. Yerkes, at whose suggestion this paper was prepared.



Bulletin of the National Research Council

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- Number 32. Moments and stresses in slabs. By H. M. Westergaard and W. A. Slater. April, 1922. Pages 124. Price \$1.00.
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